Sorption-Desorption Kinetics for Powdered and Non-Powdered Coal

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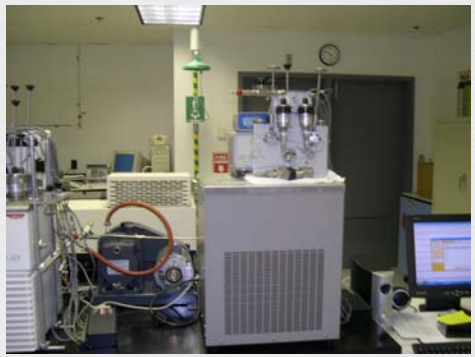
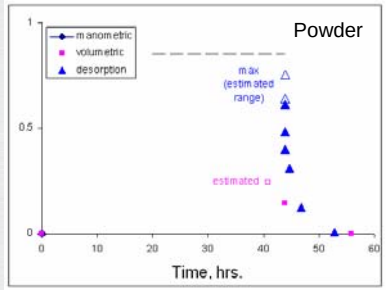
Concept:

- **Macroscopic and mesoscopic structural differences between powdered and non-powdered coals may not only influence the rates of the gas/fluid sorption-desorption kinetics but also affect the pressure dependence of the coal sorption capacity.**



- **The sample volume as well as the complementary void volume can change during the test thus contributing to the error in interpretation of the manometric and gravimetric excess sorption data**



Goal:

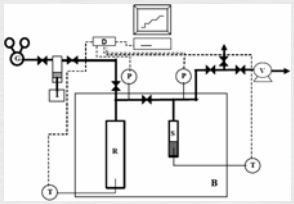
- **To verify applicability of traditional sorption/condensation models and structural changes in the coal matrix**

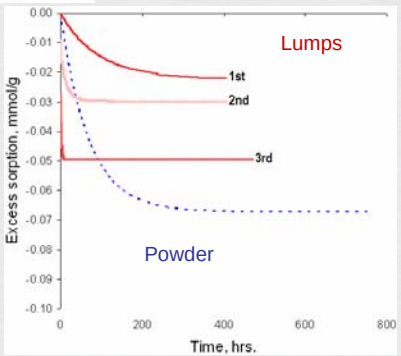
Objectives :

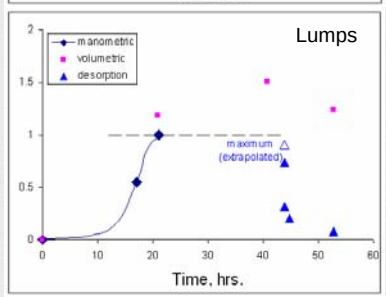
- **To measure the adsorption isotherms and sorption capacities of CO_2 on dehydrated Upper Freeport coal from the set of Argonne Premium Coal Samples under in-seam conditions, including pressures up to 15 MPa and temperatures up to 55 ^oC for gaseous and supercritical CO_2**
- **Use medium size lump and powder samples for comparative studies of the helium (He) and carbon dioxide (CO_2) sorption-desorption kinetics. Analyze the dynamic He and CO_2 excess volume data**
- **To identify and characterize any changes in coal structure caused by carbon dioxide, especially, by its supercritical phase**

$$w\cdot\Delta_v n^{ex}=\left(\frac{P_{R_i}}{z_{R_i}}-\frac{P_{R_f}}{z_{R_f}}\right)\cdot\frac{V_R}{RT}-\left(\underbrace{\frac{P_{S_f}}{z_{S_f}}}_{error}-\frac{P_{S_i}}{z_{S_i}}\right)\cdot\frac{V_o}{RT}$$

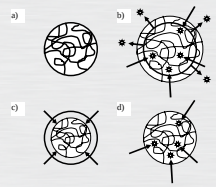
$$w\cdot\Delta_g n^{ex}=\frac{\Delta_g m}{\mu}=\frac{\Delta_a m-\rho\cdot\Delta V_S}{\mu}$$

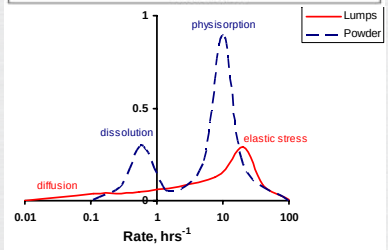






- **Models of sample's (excess) volume changes**





- **Diffusion through macro- and meso-pores with the subsequent filling of open micropores is a relatively fast process and the manometric measurements with fifteen minute pressure stabilization steps provide a good estimate of excess (ad)sorption. This can be followed by a much slower processes of the penetrant diffusion into the macromolecular network, accompanied by its structural relaxation, with or without free volume changes. The "free volume" effect is a change of the sample's excluded volume because of the penetrant molecules mixing within the formerly excluded volume of the network or because of contraction (either reversible or semi-permanent) due to external pressure. If the resulting swelling of the sample leads to the mixture's volume equal to the sum of the initial volumes of the components, there is no apparent change to the void volume and no pressure relaxation is observed (b). On the other hand, if the external forces (either macroscopic pressure or microscopic molecular interaction forces) change the excluded volume of the network (its density), without exchange of the sorbent molecules between the sample and the free fluid phase, such change causes a corresponding change in the void volume, which constitutes a pure free volume effect (c). In this case, no post-decompression exodus of the sorbent out of the sample is observed. As a special case, we consider an incorporation of the penetrant molecules into the network without any change in the volume of the mixture (d), though mathematically this can be written as a superposition of the previous two cases.**